

Diploma thesis on the topic  
Trapping of pollution by quasi-stationary anticyclones  
with focus on aircraft emissions from the North Atlantic  
flight corridor

a thesis submitted to the  
**Ludwig-Maximilians-Universität (LMU)**  
**München**  
**Institut für Meteorologie**  
produced at the  
**Institut für Physik der Atmosphäre**  
**DLR Oberpfaffenhofen**



for the degree of  
Diplom - Meteorologe  
presented by  
**Dennis Stich**  
July 2009

Examiner: Prof. Dr. Ulrich Schumann  
Co-Examiner: Prof. Dr. Martin Dameris



The cover shows a visualization of the North Atlantic flight corridor embedded between North American and European air traffic routes. Source and image with the air traffic routes for the whole world in Appendices B and C.

# Abstract

It is assumed that aircraft emissions might accumulate in stagnant anticyclones. Emissions like nitrogen oxide and chemical products of them (e.g. ozone) should have higher concentrations within such blocking anticyclones. In this context the occurrence of blocking is examined with the aid of different blocking indices and climatologies already available in the literature. For chosen example cases, in the North Atlantic region, ozone profiles from airborne field campaigns (POLINAT) and ozone sounding platforms (WOUDC) are examined to search for an aircraft emission induced production of ozone.

An analysis of different airmasses and their origin is performed by the calculation of LAGRANTO backward trajectories based on ECMWF wind fields. Taking into account potential vorticity (PV) and pressure along the trajectories together with PV charts and satellite images (EUMETSAT) possible sources for the signal in the ozone measurements are searched. These possible sources are for example boundary layer emissions, that are transported along cold fronts or convectively lifted in thunderstorms, as well as stratospheric intrusions. Some ozone profiles reveal an ozone concentration elevated about 10 nmol/mol in 9 - 10 km altitude (mean altitude for the flight corridor) that could not be traced back to the sources just mentioned. For one of the examples calculations with a Lagrangian particle dispersion model (FLEXPART) with a high resolution air traffic data base (AERO2K) are taken into account for further interpretation.

Finally, recommendations for the planing of an airborne field campaign to measure the ozone production due to aircraft emissions are given.



# Contents

<b>1. Introduction</b>	<b>3</b>
1.1. Motivation . . . . .	3
1.2. Background . . . . .	6
1.2.1. The North Atlantic flight corridor (NAFC) . . . . .	6
1.2.2. Airmass transport . . . . .	7
1.3. Aims & Outline . . . . .	9
<b>2. Blocking</b>	<b>11</b>
2.1. Definition . . . . .	11
2.2. Indices, Studies & Climatologies . . . . .	13
2.2.1. Existing blocking indices and climatologies . . . . .	13
2.2.2. Other important blocking studies . . . . .	15
2.2.3. Utilized indices and climatologies . . . . .	16
2.3. Predictability . . . . .	18
2.4. Brief summary . . . . .	20
<b>3. Data &amp; Methods</b>	<b>21</b>
3.1. Data . . . . .	21
3.1.1. Meteorological charts and satellite images . . . . .	21
3.1.2. Airborne measurements . . . . .	23
3.1.3. Blocking data . . . . .	23
3.1.4. WOUDC ozone soundings . . . . .	23
3.2. Trajectory calculations . . . . .	24
<b>4. Case studies</b>	<b>25</b>
4.1. Accumulation example of a contrail-cirrus model . . . . .	25
4.2. Blocking spring 1995 . . . . .	27
4.2.1. Ozone measurements & trajectories . . . . .	28
4.2.2. Discussion . . . . .	30
4.3. POLINAT campaign summer 1995 . . . . .	31
4.3.1. Field campaign . . . . .	31
4.3.2. Ozone measurements & trajectories . . . . .	33
4.3.3. Discussion . . . . .	40
4.4. Blocking summer 2007 . . . . .	40
4.4.1. Ozone measurements & trajectories . . . . .	41
4.4.2. Discussion . . . . .	49
4.5. Conclusions . . . . .	50
4.5.1. Ozone production . . . . .	50

---

4.5.2. FLEXPART results . . . . .	53
4.5.3. Brief summary . . . . .	56
<b>5. Recommendations for planning an airborne field-campaign</b>	<b>57</b>
<b>6. Summary &amp; Outlook</b>	<b>59</b>
6.1. Summary . . . . .	59
6.2. Remarks . . . . .	59
6.3. Outlook . . . . .	60
<b>A. Abbreviations</b>	<b>63</b>
<b>B. Links</b>	<b>65</b>
<b>C. Additional figures</b>	<b>67</b>
<b>List of Figures</b>	<b>85</b>
<b>List of Tables</b>	<b>87</b>
<b>Bibliography</b>	<b>89</b>